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Cooperative CSA Cement Sample Comparative Programme
Sample No. 43 - Test Results and Analysis

by
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ABSTRACT

This programme was designed and initiated in 1960 by the CSA Committee on Hydraulic Cements through the Sub-Committee on Physical and Chemical Requirements and Test Methods, as a means for the cement testing laboratories across Canada to evaluate their testing procedures and techniques. CANMET (formerly the Mines Branch) has been acting as an impartial center in coordinating and reporting on this round-robin cement testing program.

This brief report presents the test results and statistical analysis of the most recent cement test sample, which was distributed to the participating laboratories in the early part of 1990.

There are twenty-five participating laboratories in this testing programme: the quality control laboratories of twenty-two cement plants across Canada, one federal government laboratory, one provincial Department of Highways laboratory, and one commercial testing laboratory.

Keywords: Chemical analysis, physical tests, standard deviation, coefficient of variation, fineness, soundness, compressive strength.

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CANMET

Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

SAMPLE NO. 43 - Test Results and Analysis

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CSA CEMENT TESTING PROGRAMME *

Sample No. 43

The attached tables represent the results obtained from sample No. 43 of the Co-operative Cement Sample Comparative Programme in compliance with the CSA Committee on Hydraulic Cements. These results were obtained and reported by the participating laboratories with CANMET acting as the coordinator for this round-robin testing program.

For sample No. 43 , the cement distributed was a Normal Portland Cement , Type 10 , blended and packaged in our CANMET laboratory from a 360 kg. cement stock which was supplied to us by one of the cement distributors participating in this program.

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*Results were compiled and analyzed by K.E. Painter, Concrete Technology Section, MSL, CANMET

Sample No. 43

Summary of Statistical Analysis of Test Results - Chemical Analysis

Description of Tests	N*	Statistical Analysis of all Data Reported					
		Maximum	Minimum	Average	Range	Standard Deviation	Coefficient of Variation %
Chemical Analysis (CSA Tests)							
Loss on Ignition, %	19	1.18	0.81	0.98	0.37	0.09	9.24
Insoluble Residue, %	14	0.30	0.08	0.18	0.22	0.05	30.01
Sulphur Trioxide, %	19	4.82	4.58	4.69	0.24	0.06	1.30
Magnesia, %	18	2.60	1.97	2.15	0.63	0.15	6.90
Ferric Oxide, %	19	2.43	2.20	2.32	0.23	0.06	2.62
Aluminum Oxide, %	19	6.56	5.56	6.03	1.00	0.30	5.00
Tricalcium Aluminate,%	19	13.58	10.64	12.07	2.94	0.84	6.96
Chemical Analysis (Additional Tests)							
Silicon Dioxide, %	19	20.53	20.03	20.27	0.50	0.14	0.70
Calcium Oxide (Total), %	19	62.30	60.91	61.91	1.39	0.38	0.61
Calcium Oxide (Free), %	17	1.04	0.62	0.79	0.42	0.12	15.02
Sodium Oxide, %	19	0.29	0.15	0.19	0.14	0.04	21.26
Potassium Oxide, %	19	1.24	1.08	1.18	0.16	0.04	3.29
Magnesium Oxide, %	8	0.06	0.05	0.05	0.01	0.00	8.82
Titanium Dioxide, %	12	0.26	0.22	0.24	0.04	0.01	4.08
Phosphorus Pentoxide, %	10	0.20	0.11	0.15	0.09	0.02	14.81
Strontium Oxide, %	11	0.11	0.09	0.10	0.02	0.01	6.14
Lead Oxide, %	2	0.01	0.004	0.01	0.01	0.01	78.57
Zinc Oxide, %	3	0.01	0.004	0.01	0.01	0.00	43.30
Copper Oxide, %	3	0.04	0.001	0.02	0.04	0.02	144.68
Chloride, %	4	0.03	0.01	0.02	0.02	0.01	34.84
Fluoride, %	2	0.06	0.05	0.06	0.01	0.01	12.86

*N - Number of laboratories reporting

Sample No. 43

Summary of Statistical Analysis of Test Results - Physical Tests

Description of Tests	N**	Statistical Analysis of all Data Reported					
		Maximum	Minimum	Average	Range	Standard Deviation	Coefficient of Variation %
Physical Tests - General							
Fineness							
- Passing 45 μm, % 1 gr sample	18	88.9	83.5	86.8	05.4	1.46	1.68
- Blaine, m^2/kg	18	371	356	363	15	5.10	1.40
Soundness							
- Autoclave Expansion, %	17	0.07	0.01	0.04	0.06	0.02	36.05
Normal Consistency							
- W/C, %	18	26.5	25.4	26.0	01.1	0.33	1.28
Setting Time, min.	17	165	110	136	55	14.53	10.72
Sulphate Expansion, %	11	0.055	0.008	0.019	0.047	0.01	77.46
False Set							
- Penetration final/initial, %	18	85.0	42.0	60.1	43.0	10.87	18.07
Physical Tests - Mortar Strength*							
Compressive Strength, MPa							
- 3 Day	18	25.0	21.4	23.5	3.6	1.07	4.54
- 7 Day	18	30.7	26.9	28.8	3.8	1.11	3.85
- 28 Day	18	39.9	33.7	37.3	6.2	1.58	4.23
Flow, %	17	125	90	108	35	8.60	7.99

* Uncorrected values only.

**N - Number of laboratories reporting

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Chemical Analysis - CSA Tests

Participant	L.O.I. %	Insoluble %	SO_3 %	MgO %	Fe_2O_3 %	Al_2O_3 %	C_3A %
A							
B	1.00	0.18	4.75	2.06	2.42	5.56	10.64
C	0.95	0.12	4.65	2.08	2.30	5.84	11.59
D							
E	1.01		4.65	2.22	2.39	6.28	12.60
F							
G	0.93		4.72	2.13	2.31	5.75	11.33
J	0.94	0.18	4.68	2.25	2.30	6.18	12.49
L	1.18		4.77	2.37	2.34	6.46	13.16
M							
N	1.03		4.73	2.06	2.35	5.79	11.37
O	0.98		4.60	2.08	2.28	5.73	11.33
Q	0.89	0.16	4.66	2.06	2.36	5.86	11.54
S							
T							
V	1.00	0.20	4.70	2.60	2.35	5.95	11.80
W	0.91	0.20	4.67	2.24	2.34	6.22	12.53
X	1.14	0.24	4.82	2.06	2.25	6.56	13.58
Y							
Z	0.97	0.20	4.76	1.97	2.30	6.44	13.18
AA	0.97	0.14	4.64	2.12	2.23	6.03	12.21
BB							
CC	0.81	0.30	4.70	2.08	2.28	5.71	11.28
DD	0.84	0.23	4.58	2.07	2.20	6.39	13.22
EE	1.03	0.18	4.75		2.27	5.82	11.59
FF	1.06	0.08	4.69	2.17	2.29	6.23	12.64
HH							
JJ							
KK							
VV	0.94	0.14	4.65	2.04	2.43	5.81	11.29

Sample No. 43

Chemical Analysis - Additional Tests

Participant	SiO_2, %	CaO total%	CaO free%	Na_2O, %	K_2O, %	Mn_2O_3, %	TiO_2, %	P_2O_5, %	SrO, %	PbO, %	ZnO, %	CuO, %	CL^-, %	F^-, %
A														
B	20.26	62.10	0.93	0.15	1.16									
C	20.33	61.78	1.04	0.20	1.20	0.05	0.25	0.11	0.09		0.010	0.040	0.010	0.06
D														
E	20.13	60.91	0.75	0.16	1.23									
F														
G	20.18	61.43		0.16	1.18		0.24	0.14	0.10					
J	20.46	62.09	0.62	0.17	1.24	0.05	0.24	0.16	0.09					
L	20.36	62.13	0.77	0.29	1.18									
M														
N	20.40	62.15	0.81	0.16	1.19		0.24	0.16	0.10				0.020	0.05
O	20.44	61.92	0.98	0.18	1.13	0.05	0.25	0.16	0.10					
Q	20.39	61.80	0.90	0.17	1.19	0.05	0.26	0.15	0.10					
S														
T														
V	20.15	61.10	0.77	0.19	1.23	0.06	0.24	0.14	0.09	0.014	0.010	0.004	0.017	
W	20.03	62.30	0.74	0.21	1.20									
X	20.20	62.23	0.65	0.18	1.21	0.06	0.24	0.15	0.11					
Y														
Z	20.27	61.90	0.82	0.18	1.16									
AA	20.20	62.02	0.79	0.18	1.18	0.05	0.25	0.15	0.10	0.004	0.004	0.001	0.025	
BB														
CC	20.53	61.86	0.81	0.17	1.08		0.22		0.10					
DD	20.36	62.24	0.66	0.29	1.14									
EE	20.25	62.13	0.64	0.15	1.17									
FF	20.07	62.15		0.18	1.14		0.25							
HH														
JJ														
KK														
VV	20.10	62.03	0.76	0.17	1.18	0.05	0.25	0.20	0.10					

Physical Tests - CSA Tests

Sample No. 43

Participant	False Set				Flow %	Mortar Strength		
	Initial Consist. (ml)	Penetration 1 mm				Compressive Strength, MPa		
						Uncorrected		
		Initial	Final	Final/Initial Penetration%		3 Day	7 Day	28 Day
A								
B	136	36	26	72.0	116	24.0	29.0	36.8
C	132	30	19	63.3	125	22.6	28.7	36.6
D								
E	140	33	14	42.0		23.7	27.8	36.4
F								
G	134	35	15	43.0	112	24.1	29.3	39.9
J	135	29.5	15.5	52.5	100	23.6	28.6	36.3
L	137	31	18	58.0	90	21.4	27.0	35.9
M								
N	133	30	19	63.3	107	22.3	28.7	37.0
O	137	35	19	54.3	112	23.3	29.5	39.6
Q	134	28	20	71.4	108	22.2	26.9	33.7
S								
T								
V								
W	136	33	23	69.7	98	25.0	30.3	38.4
X	135	30.5	17	58.3	103	24.5	30.5	39.4
Y								
Z	138	33	28	85.0	104	23.7	28.3	39.0
AA	135	34	17	50.0	112	21.8	27.6	36.2
BB								
CC	135	33	19	57.6	116	23.8	28.1	37.4
DD	134	32	16.5	51.6	95	24.2	28.9	37.7
EE	136	35	21	58.3	109	24.5	29.2	35.8
FF	134	30.5	19	62.3	112	24.1	29.9	37.9
HH								
JJ								
KK								
VV	135	30	21	70.0	110	25.0	30.7	37.7

Physical Tests - General

Sample No. 43

Participant	Fineness		Soundness	Normal	Setting	Sulphate
	45µm Sieve % Passing %	Blaine m^2/kg	Autoclave Expansion %	Consistency W/C %	Time min.	Expansion %
A						
B	87.6	362	0.02	26.2	140	
C	88.3	357		26.0	115	0.015
D						
E	86.0	363	0.04	26.5	115	
F						
G	86.6	368	0.05	26.0	140	0.014
J	86.9	358	0.05	26.4	145	0.013
L	85.6	370	0.04	26.2	147	0.040
M						
N	88.0	359	0.04	25.6	155	0.012
O	86.0	358	0.07	26.1	140	
Q	87.7	368	0.04	25.4	125	0.018
S						
T						
V						
W	83.5	371	0.06	25.9	130	
X	83.7	366	0.04	25.5	140	0.010
Y						
Z	87.2	357	0.05	26.0	165	0.008
AA	88.2	364	0.05	26.4	142	0.011
BB						
CC	86.8	371	0.01	25.5		
DD	87.1	360	0.04	26.2	125	0.013
EE	88.9	361	0.02	26.3	110	
FF	87.8	356	0.06	26.2	131	0.055
HH						
JJ						
KK						
VV	86.9	365	0.06	25.8	140	